

CHAPTER 2

PETROLEUM PRODUCTS

Section I. Petroleum-Base Liquid Propellants and Fuels

CRUDE PETROLEUM

Crude petroleum is a mixture of many complex hydrocarbons, all of which have different boiling points. By the process of distillation, the various hydrocarbon compounds in crude oil can be separated physically into groups of hydrocarbons having similar boiling ranges. These groups of hydrocarbons are known as fractions or cuts. The common fractions yielded from crude oil include: butanes and lighter cuts; straight-run gasoline cut; naphtha cut; kerosene cut; gas and lube oil cut; and residue cut. The quantity (percentage) of each cut, per barrel, varies according to the geographic origin of the crude oil. After the initial separation process into fractions or cuts, there are additional refining processes necessary to produce finished petroleum products for use by the consumer.

TYPES OF PETROLEUM PRODUCTS

Petroleum products are grouped into four main categories: (1) petroleum-base liquid propellants and fuels; (2) fuel oils; (3) cutting, lubricating, and hydraulic oils and greases; and (4) miscellaneous chemical specialties. These categories are discussed in the following paragraphs. Specifications listed in these paragraphs can be obtained from the Department of the Navy, Navy Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

PETROLEUM-BASE LIQUID PROPELLANTS AND FUELS CATEGORY

Petroleum-base liquid propellants and fuels include aviation gasoline, automotive gasoline, jet

or turbine fuels, and diesel fuel. These propellants and fuels are discussed below.

Aviation Gasoline. AVGAS is the fuel used in all piston aircraft engines. The most important properties of aviation gasoline are: volatility; knock value; vapor pressure; stability; and solvent or corrosion properties. Some of the characteristics of aviation gasoline are listed below.

- They are mixtures of hydrocarbons that boil in the approximate range of 90-338°F.
- They have a gravity range of about 66°-72° API.
- Gasoline hydrocarbon molecules have approximately 5 to 9 carbon atoms (C₅ - C₉). (Those hydrocarbons with fewer carbons are normally gases.)

Producing a satisfactory fuel for aircraft and for all gasoline-driven piston engines is largely a matter of blending and controlling the proportions of various hydrocarbons. Sometimes the process includes altering the structures of the hydrocarbons. AVGAS is manufactured according to ASTM specification D 910. The gasolines are manufactured in three grades: 80 (red or clear and containing no lead); 100/130 (green); 100/130LL (blue).

Motor Gasoline. During the refining process, MOGAS is derived from that fraction of crude oil within a boiling range of 90°- 420°F. The components in MOGAS do not have to be controlled within the same narrow limits as AVGAS. In MOGAS more of the valuable aromatics can be used, and more alkenes and alkanes are acceptable than in MOGAS due to less restrictive stor-

age requirements. MOGAS differs from AVGAS mainly in volatility and antiknock properties. They also differ in vapor pressure. Because of these differences, the use of MOGAS in aircraft is unsafe unless both the aircraft engine and the aircraft itself have been adapted for its use. Two types of MOGAS are discussed below:

- Commercial MOGAS is supplied under the ASTM specification D 4814. The specification covers special, regular, and premium grades in classes A, B, C, D and E to suit climatic conditions. Additionally, ASTM D 4814 covers oxygenated gasoline blends which are required in certain geographical regions of the United States to reduce CO₂. Gasohol is gasoline with 10 percent (by volume) ethanol. It is used as an alternate fuel and supplied in the same grades and classes as commercial gasoline. Gasohol is intended for use where long-term storage is not anticipated. It is procured under CID A-A-52530.

- Combat MOGAS is suitable for use in all gasoline engines, other than aircraft, under all conditions of service. Gasoline in this category is supplied under specification MIL-G-3056 in type I for use at all temperatures above 0°F (-18°C) and in type II for use where the mean temperature is consistently below 32°F (0°C).

Jet or Turbine Fuels. Jet or turbine fuels required for jet aircraft engines are obtained from special kerosene and gasoline fractions of crude oil. Fuel used in jet aircraft engines, should contain the properties listed below.

- The fuel must contain as much heat energy as possible both per unit weight and per unit volume.
- Combustion properties, which are related both to chemical composition and volatility, must be as good as possible.
- The fuel must have a low freezing point due to the low temperature encountered by jet aircraft flying at high altitudes for long periods of time.

Other areas of consideration are listed below.

- Loss of fuel in flight by evaporation.
- The fuel should be non-corrosive.

- The fuel should not clog fuel filters.
- The fuel should not produce vapor lock or slugging. (Slugging is the loss of liquid fuel from the vents owing to the pulling action of escaping vapors.)

JP-4, JP-5, JP-7, JP-8, JET A-1. Available jet or turbine fuels are: JP-4, JP-5, JP-7, JP-8 and JET A-1. A primary consideration in the development of any petroleum fuel is its availability in relation to other needed fuels, all of which must come from the same batch of crude oil. Generally, gasoline producers cannot produce as much jet or turbine fuel as gasoline because a barrel of crude oil contains about twice as much material in the gasoline range as in the jet-diesel range. These fuels are discussed below.

- JP-4 fuel is a wide-cut, gasoline base jet fuel procured under MIL-T-5624. The use of JP-4 is limited to geographical regions where extreme cold weather conditions exist. The boiling point for this particular type of gasoline base fuel is in the approximate range of 120° to 500°F, and it has low vapor pressure (2.0 to 3.0 psi, Reid). JP-4 is not the preferred fuel because of the inherent ignition hazards in this cut of fuel. Jet fuel supplied under MIL-T-5624 may be required to contain 0.10 to 0.15 percent by volume of FSII. The FSII used in JP-4 is DIEGME and must conform to MIL-I-85470. JP-4 may contain a SDA. Currently there are two that have been approved, ASA-3 and STADIS 450. These SDAs increase the conductivity of the fuel and allow static electricity to dissipate rapidly. Because the additives are surfactants, the WSIM test is not run on JP-4 containing an SDA. The additives are usually blended in a concentration of 1.0 part per million. This yields a conductivity rating of 200-600 pS/m or 200 to 600 CUs. The API gravity range for JP-4 is from 45.0 to 57.0.

- JP-5 is a narrow-cut, kerosene-base jet fuel procured under MIL-T-5624. It was originally developed for use by aircraft carrier planes where a safer fuel than JP-4 was required for storage aboard the carrier, and is now used by all sea-based aircraft. The boiling point for this cut of fuel

is within a range of 400° to 600°F. It has a high flash point, (149°F) and the vapor pressure is less than 1 psi. Since JP-5 is supplied under MIL-T-5624, it also must contain a FSII. Because of its high flash point the preferred FSII in JP-5 is DIEGME, with a required concentration level of 0.15 to 0.20 percent by volume. DIEGME shall conform to MIL-I-85470. The API gravity range for JP-5 is from 36.0 to 48.0.

- JP-7, a thermally stable fuel, is a kerosene-base fuel procured under MIL-T-38219. It is used by the Air Force for specific application in which higher thermal stability is required. It is not intended for general acquisition, but is a limited production item for use only in engines that require this product.

- JP-8 is a kerosene base aviation turbine fuel procured under MIL-T-83133. Development of JP-8 is a result of battlefield damage that had shown JP-8 was inherently a safer fuel (for example, less susceptible to ignition and sustained fires). Also, JP-8 is essentially identical to JET A-1 and would be commercially available worldwide. The API gravity range for JP-8 is from 37.0 to 51.0. JP-8 is JET A (CONUS) or JET A-1 (OCONUS) combined with the additives: FSII, SDA and Corrosive Inhibitor. JP-8 has been established as the single fuel for the battlefield by DOD directive. JP-8 is used in both aviation turbine engines and compression ignition engines.

- JET A (CONUS) and JET A-1 (OCONUS) aviation turbine fuel is essentially identical to JP-8 except it does not contain the

three additives required in JP-8. JET A/JET A-1 is the standard fuel used by commercial airlines worldwide. It is procured under ASTM D 1655.

Diesel Fuel. Diesel fuel can be classified in either the petroleum-base liquid propellants and fuels category or the fuel oils category. It is used in diesel engines and depends on the heat of compression of an air charge for ignition. Diesel fuel is graded according to its use. DFM is procured for use on ships under military specification MIL-F-16884. Diesel fuels used in certain turbine and compression-ignition engines are procured under the Commercial Item Description A-A-52557 in Grade Low Sulfur No. 1-D (DL1) and Grade Low Sulfur No. 2-D (DL2). Diesel fuels may also be used in place of light burner fuels. Diesel fuel properties that have considerable influence on the performance and reliability of a diesel engine are listed below.

- Ignition quality.
- Volatility.
- Tendency to form carbon deposits on engine parts.
- Viscosity.
- Sulfur content.
- Ash and sediment.
- Flash point.
- Pour point.
- Acidity.

Section II. Fuel Oils

BURNER FUELS

Burner fuels are used in boilers or furnaces to generate power or heat. These liquid fuels have several advantages over solid fuels. These advantages are:

- Greater heating value on a weight or volume basis so that less storage space is required.

- More efficient combustion because of better contact between fuel and air under conditions of use and an almost complete absence of ash.

- Greater ease of handling and firing.

- Greater heat input for a given combustion space.

Classes of Burner Fuels. Two classes of burner fuels: military and commercial, are discussed below.

- Military burner fuels are procured under military specification, MIL-F-859, in grade Navy Special for use in steam-powered vessels. Specifications for these fuels are not exacting, but compatibility is sometimes of concern to the user. Different lots of fuel procured on a worldwide basis must be compatible because some burner fuels, stable when stored separately, may not be stable in combination.

- Commercial burner fuels are procured under ASTM Specification D 396 and are intended for general heating purposes. There are seven grades established in this class of burner fuels: No. 1, No. 2, No. 4, No. 4 (light) No. 5 (light), No. 5 (heavy) and No. 6. These fuel oils differ chiefly

in viscosity and gravity and in types of burners required for use. Some fuels require preheating before combustion takes place, and burners used with these fuels must have preheaters.

KEROSENE

Kerosene is used by the military services as an illuminating oil, for space heating and for other general purposes such as cleaning tools and equipment. It is supplied under ASTM Specification D 3699 in grade K-1 (low sulfur, mandatory for use in nonflue connected burner appliances) and grade K-2 (for other burner applications). Good quality kerosene boils in the approximate range of 300° to 572°F. Thus, there is an absence of heavy ends or extremely high boiling point fractions that interfere with clean burning in lamps or complete vaporization in stoves. Also, the absence of light ends or very low boiling point fractions gives the kerosene a relatively high flash point to secure safety in handling, storage, and burning.

Section III. Lubricating Oils and Greases

PURPOSE

The primary purpose of any lubricant is to reduce friction, which would eliminate metal-to-metal contact. Lubricating oils provide a film that permits surfaces to glide over each other with less friction. Therefore, lubrication is essential to prevent wear in any mechanical device where there are surfaces rubbing against each other. Oils are also used to clean, seal, and cool the equipment. The selection of the proper lubricating oil for a given application depends upon the design of the equipment and the condition under which the equipment is to be operated.

LUBRICATING OILS

Many lubricating oils are produced from the light and heavy lubricant fractions of crude oil. Some are made from steam or vacuum distillates,

some from residual stocks, and some from blends of distillates and residuals. Distillate stocks contain

substances in the approximate (C₂₅ - C₄₀) range; residual stocks contain substances in the (C₅₀ - C₈₀) range. These oils boil in the range of 300° to 1,000° F. The nature of these oils varies from spindle oils, which are only a little more viscous than kerosene, to highly viscous and heat-resistant aircraft engine oils. Generally, topped crudes are subjected to vacuum distillation to separate the various lubricant cuts. Refining removes most of the undesirable components such as wax, asphalt, and oxidizable impurities. After refining, stocks are blended and compounded with fatty materials, as necessary to achieve desired results. Various additives are blended in to delay oxidation and formation of acids and suppress crystallization of wax. This blending process also lowers the pour point, promotes oiliness, strengthens the lubricating

film, reduces foaming, improves the viscosity index, and supplies a detergent and dispersant quality to the lubricant. Increased use of synthetic base oils will lessen the demand for petroleum base lubricants.

REQUIREMENTS

Lubricating oils used by the military are too numerous to list in this publication. The ARMYLOG/FEDLOG has a complete list of petroleum products and identifies the appropriate

specifications. A great volume of lubricating oils is included in three important categories: military

symbol oils, crankcase oils, and gear oils. Selected large volume oils procured in these categories are shown in Table 2-1. (All of the oils listed there have petroleum bases except the last two, which have synthetic bases.) Table 2-2 lists the SAE numbers and military symbol equivalents of various lubricating oils.

Table 2-1. Lubricating oils and specifications

Specification	Product
MIL-L-2104	OE/HDO-30, OE/HDO-40, and OE/HDO 15/40 multi-weight oils
MIL-L-2105	GO-80/90, and GO-85/140
MIL L-6081	MS 1005 and MS 1010
MIL-L-6082	MS 1080, 1100 and 1120
MIL-L-9000	MS 9250
MIL-L-17331	MS 2190 TEP
MIL-L-53074	MS 5190, 5230
MIL-H-17672	MS 2075TH, 2110TH, 2135TH
MIL-L-7808	Symbol LGT (Synthetic Base)
MIL-L-23699	Lubricating Oil, Aircraft, Turbine (Synthetic Base)

Table 2-2. SAE numbers and military symbol equivalent

SAE No.	Military Symbol Oils
10W	OE/HDO-10, 1010
20W	2075, 2110
30	2190 TEP, 9250, 1065, OE/H00-30, 2135, 6075
40	OE/HDO-40, OE/HDO 15-40
50	1100, GO 80/90
140	5190, GO 85-140
250	5230

LUBRICATING GREASES

In general, grease should not be used where oil will perform the necessary lubrication. There are conditions however when grease is a more suitable lubricant. Grease is used in bearings, which, because of their nature, are unable to retain oil. Grease is also used in inaccessible bearings where the grease is applied by grease cups. Under dirty atmospheric conditions, the use of grease is advisable as it seals the ends of the bearings and thus prevents dust and dirt from entering the bearings. Also, it is preferred in food processing plants and paper and textile mills where drip and splatter must be avoided.

CLASSIFICATION OF GREASES

Greases are classified according to their soap base or thickener. These, in turn, govern the properties and application of the lubricant in a general way. The soaps used are derived from fatty animal or vegetable oils such as tallow or cottonseed. New greases include: disperses of soap in nonpetroleum liquids, and nonstop thickeners in petroleum oils. A third type of grease, nonpetroleum-nonsoap, consists of such substances as silicone liquids thickened with alkyl ureas. General classes of greases are as follows:

- Calcium Base Grease. Calcium base greases containing low viscosity oils are cup greases. Those containing slightly more viscous oils are pressure gun greases. These are used in relatively slow moving bearings. The greases are water resistant, but they do not retain consistency well at high temperatures.
- Sodium Base Grease. Sodium base greases, containing the more viscous oils, will hold up in situations where high temperatures can be expected. They are soluble in water. These greases are used in gears and in faster moving bearings.
- Lithium Base Grease. Lithium base greases are water resistant and possess good low temperature characteristics. They are more costly than calcium and sodium base greases and their use is often restricted to low volume applications.
- Aluminum Base Grease. Aluminum base greases are water resistant and retain consistency

well at moderate temperatures. They combine the characteristics of both calcium and sodium base greases. Aluminum base greases are used for gears, for reciprocating parts, and for the lubrication of equipment used in food and textile mills.

- Barium Base Grease. Barium base greases are water resistant and can be used at high temperatures.
- Mixed Base Grease. Mixed base greases are used where calcium or sodium base greases cannot be used. Mixed base greases are used on high-speed, anti-friction bearings under wet conditions and for the lubrication of steam-heated calendar rolls in paper and textile mills.

GREASE REQUIREMENTS

Some of the large volume greases used by the Army include industrial, general-purpose grease, (supplied under federal specification VV-G-632); automotive and artillery grease, (supplied under military specification MIL-G-10924); and ball and roller bearing grease, (supplied under specification DOD-G-24508).

PROPERTIES OF GREASE

Essential properties of greases include appearance, penetration (worked), stability, corrosion, resistance to aqueous solutions, dropping point, fuel resistance, odor, free acidity, oxidation, and oil separation.

MISCELLANEOUS PRODUCTS

The following petroleum products are categorized in the miscellaneous category:

- Paraffin waxes and petrolatum (used in packing and sealing rations, and for dipping munitions to prevent rust and corrosion).
- Cutting oils (used as cooling mediums and lubricants for specific machine operations).
- Solvents (used as paint thinners and for cleaning metal surfaces and bearings, also used in the dry cleaning of clothes).
- Insulating oils (used as insulating and cooling medium for certain transformers).
- Asphalt (used for airstrips and for roofing).

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- Medicinal products.
- Fungicides and insecticides.